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IS 15803 (2008): Respiratory protective devices - Self contained closed circuit breathing apparatus chemical oxygen (KO2) type self generating, self rescuers [CHD 8: Occupational Safety, Health and Chemical Hazards]

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श्वसन संरक्षी युक्तियां — स्वतः पूर्णबंद परिपथ श्वसन उपकरण, रसायन ऑक्सीजन (KO_2) टाइप, स्वतः उत्पादन, स्वतः रेस्कुयर्स — विशिष्टि

Indian Standard

RESPIRATORY PROTECTIVE DEVICES — SELF CONTAINED CLOSED CIRCUIT BREATHING APPARATUS CHEMICAL OXYGEN (KO_2) TYPE, SELF GENERATING, SELF RESCUERS — SPECIFICATION

ICS 13.340.30

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

June 2008

Price Group 10

Occupational Safety and Health and Chemical Hazards Sectional Committee, CHD 8

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Occupational Safety and Health and Chemical Hazards Sectional Committee had been approved by the Chemical Division Council.

Breathing apparatus is one of the most important life saving equipment. To ensure the quality of these equipments, IS 10245 on breathing apparatus was published in four parts. Part 1 dealing with closed circuit breathing apparatus, Part 2 dealing with open circuit breathing apparatus, Part 3 dealing with fresh air hose and compressed air line, and Part 4 dealing with escape breathing apparatus. The filter self rescuers (FSR) once universally accepted as standard equipment for miners has been gradually replaced in a number of countries by chemical oxygen (KO_2) type self generating, self rescuers.

Chemical oxygen (KO_2) type self generating, self rescuers are used for escape by miners/persons from irrespirable atmosphere after an explosion/similar situation, to a safe place within a reasonable time. These are self contained closed circuit breathing apparatus for escape. In these apparatus breathing gas exhaled by the wearer of apparatus enters into a circuit via, facepiece or mouthpiece containing a cartridge with chemical(s) that absorbs both exhaled carbon dioxide and humidity and releases oxygen into the breathing bag where it is available for rebreathing. The gas flow may be of the pendulum or loop type and excess gas is ejected via a relief valve.

There is no ISO Standard on the subject. Considerable assistance has been derived form EN 401:1993 'Respiratory protective devices: Self contained chemical oxygen type self generating closed (KO_2 type)' to develop this standard.

It is recommended that reference should be made to IS 9623 : 2007 'Selection, use and maintenance of respiratory protective devices' for guidance on the type of respiration protection that should be provided for particular conditions — Code of practice (*first revision*)'. In addition, care should be taken in the choice of breathing apparatus itself, where such equipment is to be used in very high (60 ± 3°C) or very low (–30 ± 3°C) ambient temperatures and the instructions provided by the suppliers should be carefully noted.

Certain toxic substances which may occur in some atmospheres can be absorbed by the skin. Where these do occur, respiratory protection alone is not sufficient and the whole body should be protected.

The composition of the Committee responsible for the formulation of this standard is given at Annex K.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

AMENDMENT NO. 1 MAY 2009
TO
IS 15803 : 2008 RESPIRATORY PROTECTIVE DEVICES — SELF CONTAINED CLOSED CIRCUIT BREATHING APPARATUS CHEMICAL OXYGEN (KO_2) TYPE, SELF GENERATING, SELF RESCUERS — SPECIFICATION

(*Page* 4, *clause* **5.19.2**) — Add the following Note at the end:

'NOTE — To give the industry time to develop the facility for quick starter system, the requirement of **5.19.2**(b) shall be applicable after a period of two years from the date of publication of this amendment.'

(CHD 8)

Reprography Unit, BIS, New Delhi, India

Indian Standard

RESPIRATORY PROTECTIVE DEVICES — SELF CONTAINED CLOSED CIRCUIT BREATHING APPARATUS CHEMICAL OXYGEN (KO_2) TYPE, SELF GENERATING, SELF RESCUERS — SPECIFICATION

1 SCOPE

1.1 This standard prescribes requirements for chemical oxygen (KO_2) type self generating, self rescuers and its methods of tests.

1.2 This standard excludes devices for work and rescue or to diving apparatus.

NOTE — For testing as per this standard if for any reason a complete apparatus is not tested then simulation of apparatus is permitted provided the respiratory characteristics and mass distribution are similar to those of the complete apparatus.

2 REFERENCES

The following standards contain provisions which, through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
4905 : 1968	Methods of random sampling
8347 : 2008	Respiratory protective devices— Definitions classification and nomenclature of components (*first revision*)
14166 : 1994	Respiratory protective deices: Full face masks — Specifications

3 TERMINOLOGY

For the purpose of this standard the definitions given in IS 8347 and the following shall apply.

3.1 Exhaled Air — The air breathed out by the wearer.

3.2 Inhaled Air — The air breathed in by the wearer.

3.3 Nominal Working Duration — Maximum period of time for which the apparatus should be used in minutes or hours.

3.4 Rated Duration — Duration in steps of 5 min up to a duration of 30 min and thereafter in steps of 10 min.

3.5 Service Life — The period for which the apparatus will serve as an effective escape apparatus for its rated duration when the apparatus is being issued every day to a worker.

4 CLASSIFICATION

Chemical oxygen (KO_2) type escape apparatus are classified according to the nominal rated duration, which is defined by performing a breathing machine test in accordance with **A-1** with a minute volume of 35 l/min.

5 REQUIREMENTS

5.1 Design

a) The apparatus shall be of reliable construction and as compact as possible.

b) The apparatus shall be so designed that its outer surface can be cleaned easily and there shall be no parts or sharp edges likely to be caught on projections in narrow passages, and no sharp edges or burrs on surface of any part of the apparatus likely to be in contact with the wearer.

c) The apparatus shall prevent ingress of external atmosphere within the limits set out in this standard. It shall prevent the chemical from entering the wearer's respiratory tract and that saliva or condensate shall not interfere with the function of the apparatus or cause any harmful effect to the wearer, during practical performance test in accordance with Annex B.

d) The apparatus may be fitted with a quick starter system to generate 5-6 litres of oxygen in the breathing bag on the opening of the apparatus before use.

NOTES

1 Parts which are designed for training apparatus shall not be interchangeable with the working apparatus and shall be clearly marked accordingly or manufactured in such a way that they can not be inadvertently fitted to working apparatus.

2 It shall not be possible to initiate a quick start system (if fitted) inadvertently fitted to a working apparatus.

5.2 Materials/Components

5.2.1 The material of carrying container and the locking device, if provided, shall be adequately protected against corrosion. Exposed parts of the SCBA which may be subjected to impact during use of the apparatus shall not be made of aluminium, magnesium, titanium or alloys containing such proportions of these metals, as will, on impact give rise to frictional sparks capable of igniting flammable gas mixtures.

5.2.2 The materials used shall be able to withstand temperatures and mechanical stress whilst being carried on the person as well as on machines and vehicles when tested as per Annex B for practical performance testing and Annex C for resistance to temperature test.

5.2.3 The insulation resistance of non-metallic containers shall not exceed 10^9 ohms when tested as per Annex D for insulation resistance. Where the apparatus is required to be anti-static during escape materials used shall be anti-static as far as practicable.

5.2.4 Materials which come into direct contact with the wearer's skin and the breathable gas shall not be known to cause irritation or any other adverse effect to health.

5.3 Cleaning and Disinfection

All parts requiring cleaning and disinfection shall be able to withstand the use of cleaning and disinfecting agents and procedures as recommended by the manufacturer.

5.4 Mass

The mass of the complete apparatus including carrying container shall not exceed 5 kg. Mass of an apparatus intended for use in mines with the rated duration of up to 30 min shall not exceed 2.5 kg and above 30 min shall not exceed 4.0 kg.

5.5 Harness

The apparatus shall be provided with a harness to allow quick, easy and correct donning of the apparatus without assistance.

5.6 Handling

If the apparatus is fitted with a special lock, the design shall be such that it cannot be opened inadvertently. If the apparatus has been opened, a clear indication of this shall be given on the outside of the apparatus.

5.7 Leak Tightness

The carrying container shall remain leak tight even over an extended period of time. The leak tightness of the complete device including carrying container shall be checked by total immersion in water or an equivalent procedure specified by the manufacturer. The pressure change during leak-tightness test shall not exceed 0.3 mbar within 1 min when tested as per Annex E. The apparatus should have a suitable indicator to indicate leak tightness of the apparatus.

5.8 Facepiece

5.8.1 The facepiece shall be a mouthpiece assembly or a full face mask and shall be attached securely to the apparatus.

NOTE — Normally the facepiece should be a mouthpiece assembly with two teeth bites and a permanently attached nose clip.

5.8.2 The mouthpiece shall facilitate reliable sealing and by any means it shall not block inadvertently the breathing circuit when the apparatus is in operation. The mouthpiece assembly shall be fitted with an adjustable or self-adjusting head harness, if it is likely that an undue load is exerted on the wearer's mouth.

5.8.3 The nose clip shall provide an air-tight seal of the nose. It shall be attached to the mouthpiece assembly flexibly such that when fitting the mouthpiece the wearer's attention is automatically drawn to the nose clip.

5.8.4 In case a full face mask is used as a facepiece the following requirements shall be met:

a) The full face mask shall be provided with an adjustable or self-adjusting head harness and shall meet the requirements specified in **4.11.1** and **4.11.3** of IS 14166.

b) The lens of the full face mask shall meet the requirements for eyepieces and visors in IS 14166 except the requirement for the field of vision.

c) The face seal leakage of the full face mask shall be tested separately and shall meet the requirement specified in **4.7** of IS 14166.

5.9 Goggles

5.9.1 If the device is to be used with goggles, then the lenses of the goggles shall be protected against fogging. The head straps of the goggles shall be flexible and easily adjustable or self-adjusting. The goggles shall be attached to the apparatus to prevent loss when opening the carrying container.

5.9.2 The goggles shall not interfere with the donning of the apparatus during the practical performance test as per Annex B.

5.10 Inhalation and Exhalation Valves

The design shall be such that it shall not be possible to fit inhalation and exhalation valves in an incorrect manner.

5.11 Relief Valve

5.11.1 When the apparatus is provided with a relief valve it shall function properly irrespective of the orientation of the apparatus and shall be protected against dirt and mechanical damage. Means shall be provided for sealing the relief valve to permit leak testing of the apparatus.

5.11.2 *Opening Pressure*

The relief valve shall open at a positive pressure of not less than 1 mbar.

When the relief valve is positioned in the breathing circuit before the regeneration cartridge then the pressure drop between the relief valve and the entry of the breathing bag shall in no case be greater than the minimum opening pressure of the relief valve recorded in accordance with **F-1**.

5.11.3 *Inward Leakage*

If the relief valve is a downstream type (valve closing against pressure) then it shall be so designed that the inward leakage of the external atmosphere shall not exceed 0.002 5 percent when the moist valve is tested in accordance with **F-2.1**.

If the relief valve is a mechanically operated upstream type (valve closing with pressure) then it shall be sufficiently leak tight to withstand an outside positive pressure of 10 mbar without exceeding a pressure drop of 1 mbar in 1 min when tested in accordance with **F-2.2**.

5.12 Breathing Bag

The breathing bag and its materials shall be able to withstand the expected stress. The effective volume of the breathing bag shall be at least 6 liters when tested in accordance with Annex G.

NOTE — Additional protective measures may be required for enabling the breathing bag and its materials to withstand the expected stress.

5.13 Resistance to Temperature

The apparatus shall meet the following requirements of leak tightness and performance when the apparatus is brought to room temperature after the temperature test in accordance with **C-1**:

a) The carrying container shall be leak tight when tested for leak tightness in accordance with **E-1**.

b) The apparatus shall be functionable at a temperature of –5°C and shall meet the requirements for oxygen content and carbon dioxide content when tested in accordance with **C-2**.

NOTE — At the beginning of the test at the breathing machine the carbon dioxide content of inhalation gas may exceed the average for a short period but shall not exceed 3 percent (by volume).

c) The materials used shall not show deteriorations (severe deformations, cracks, etc).

d) The apparatus shall be leak tight when tested in accordance with **E-2** at a minute volume of 35 l/min and 70 l/min as per **A-1** and **A-2**.

5.14 Flammability

5.14.1 Those parts of the apparatus that deemed to be of an exposed nature shall be tested in accordance with Annex H for flammability test. Components shall be considered to be flame resistant if they do not burn or if they are self-extinguishing within 5 s after removal from the test flame.

5.14.2 After the test the apparatus shall still be leak tight when tested in accordance with Annex E.

5.15 Mechanical Strength

After testing the apparatus for mechanical strength in accordance with Annex J the apparatus shall be leak tight in accordance with **E-2**, provide protection and meet the performance requirements at a minute volume of 35 l/min when tested for general laboratory performance in accordance with **A-1**.

5.16 Performance

5.16.1 *Rated Duration*

The apparatus shall cover a duration laid down for its class for testing at 35 l/min. The duration shall be at least 3 times longer for testing with 10 l/min when tested in accordance with **A-1**.

5.16.2 *Minute Volume*

The apparatus shall at all times provide the necessary volume flow rate without causing any difficulty to breathing when tested in accordance with Annex B.

The apparatus shall comply with the requirements of **5.16.3** for oxygen content, **5.16.4** for carbon dioxide content, **5.16.6.2** for breathing resistance for 5 min at 70 l/min or for 30 percent of the manufacturer's claimed duration at 70 l/min whichever is the lesser period when tested in accordance with Annex A for laboratory performance test, and **A-2** for performance at high minute volume.

5.16.3 *Oxygen Content*

For all tests for practical performance in accordance with Annex B and laboratory performance Tests in accordance with Annex A the oxygen content of the inhaled gas shall be minimum 21 percent (by volume).

A short term deviation to a level of minimum 17 percent (by volume) and for a period of maximum 2 min at the beginning of the test is permissible.

5.16.4 *Carbon Dioxide Content*

Throughout the test of practical performance test in accordance with Annex B and laboratory performance test in accordance with Annex A during the rated duration of the apparatus the carbon dioxide concentration of the inhaled gas shall have maximum average value of 1.5 percent (by volume) and shall at no time exceed 3.0 percent (by volume).

For apparatus with a rated duration up to 15 min the carbon dioxide content shall not exceed a value of 3 percent (by volume).

5.16.5 *Temperature and Humidity*

For apparatus with a rated duration of up to 15 min the temperature of the inhaled gas irrespective of humidity shall not exceed 55°C, when tested at 35 l/min during the rated duration when tested for general laboratory performance test in accordance with **A-1**, laboratory performance test.

The apparatus shall not cause any intolerable drying out of the respiratory tract when tested for practical performance test in accordance with Annex B.

5.16.6 *Breathing Resistance*

5.16.6.1 *Breathing resistance at 35 l/min*

The apparatus shall confirm the following test when tested general laboratory performance test in accordance with **A-1** and **A-4** for breathing resistance:

a) For apparatus with a rated duration of up to and including 30 min the sum of the inhalation and exhalation resistances shall be maximum 16 mbar and the individual breathing resistance for inhalation or exhalation shall be maximum 10 mbar.

b) For apparatus with a rated duration of more than 30 min the sum of the inhalation and exhalation resistance shall not exceed 13 mbar and the maximum individual breathing resistance for inhalation or exhalation shall not exceed 7.5 mbar.

5.16.6.2 *Breathing resistance at 70 l/min*

For apparatus of all rated durations the breathing resistance for inhalation as well as for exhalation shall not exceed 20 mbar when tested in accordance with **A-2** for performance test.

5.17 Surface Temperature

During laboratory tests in accordance with Annex A the maximum surface temperature of the apparatus shall be determined and stated in the test report. During a practical performance test in accordance with Annex B test the surface temperature of the apparatus shall be acceptable to the wearer when dressed in a simple cotton vest.

5.18 Practical Performance Test

In addition to the machine tests described, the apparatus shall also undergo practical performance tests described in Annex B. It serve the purpose to check the apparatus for imperfection that cannot be determined by the tests described elsewhere in this standard.

At the time when the apparatus is rejected by the wearer or when the inhalation breathing resistance reaches 35 mbar, the level in the inhalation air of oxygen shall be at least 17 percent (by volume) and the level of CO_2 shall not exceed 5 percent (by volume).

Where, in the opinion of the testing authority, approval is not granted because practical performance tests show the apparatus has imperfections related to weare 's acceptance, the testing authority shall describe the tests which revealed these imperfections. This will enable other test stations to duplicate the tests and assess the results thereof.

5.19 Additional Requirement for Apparatus Designed for Special Use

5.19.1 *Transport*

5.19.1.1 Apparatus for transportation on man, machine or vehicle shall withstand heavy mechanical stress occurring during these tests.

5.19.1.2 The apparatus, if used for mining, shall be transported for a period of 3 months for 2 shifts per day. The apparatus may be carried on the man or transported on vehicles or machines when in use in accordance with the instructions of the manufacturer.

After completion of the exercises the persons responsible for the tests shall be asked for comments. The result of the examination will be taken into consideration by the testing authority for final evaluation of the apparatus.

5.19.1.3 Additionally, cleaning of the apparatus shall be tested during these trials.

5.19.1.4 After the tests the apparatus shall still be leak tight, when tested in accordance with Annex E for leak tightness provide protection and meet the physiological requirements when tested with 35 l/min in accordance with **A-1** for general laboratory performance test.

5.19.2 *Mining*

All apparatus intended for use in mines shall meet the following additional requirements:

a) The rated duration shall not be less than 30 min,
b) There shall be a provision for the quick starter system for initial spurt of oxygen, and
c) A suitable leak tightness indicator shall be provided.

6 INSTRUCTION FOR USE

6.1 Every apparatus manufactured in compliance with this standard shall be accompanied by operating instructions for use and maintenance both in Hindi and English language.

Every apparatus manufactured in compliance with this standard shall be accompanied by operating instructions for use and maintenance and use.

The instructions for use shall include all information necessary for trained and qualified persons on following points for the apparatus:

a) Application/limitation,
b) Maximum surface temperature during use,
c) Checks prior to use,
d) Donning and fitting,
e) Use,
f) Maintenance (preferably separately printed instructions),
g) Inspection intervals,
h) Shelf life,
j) Service life, and
k) Storage.

6.2 The instructions shall be unambiguous. If helpful, illustrations, part numbers, marking, etc, shall be added.

6.3 The instructions for use shall be complimented by an easy to understand picture (pictogram) on the carrying container showing the donning procedure (size at least 3 cm × 3 cm). For apparatus with a rated duration up to 30 min the pictograms my be supplied separately if there should be no sufficient place on the carrying container.

6.4 Warning shall be given against possible problems likely to be encountered, for example:

a) Intactness of the apparatus during carriage or transport,
b) Procedure of donning, and
c) Use of the apparatus in explosive atmosphere.

7 MARKING

7.1 The manufacturer, supplier or importer shall be identified by name, trade-mark or other means of identification on both apparatus and facepiece if used. The apparatus and its packaging shall be marked with:

a) Type-identifying marking;
b) Rated duration;
c) Apparatus complying with **5.17** designed for special use shall be marked with 'S'. Additional approval mark from mining/user organization can also be marked;
d) Serial number; and
e) Year of manufacture/shelf life (if applicable).

7.2 Where the reliable performance of piece parts may be affected by ageing, means of identifying the date (at least the year) of manufacture shall be given on that component/part.

7.3 Sub-assemblies and components with considerable bearing on safety shall be marked so that they can be identified. If sub-assemblies with considerable bearing on safety cannot be marked, the information shall be given in the instructions for use.

7.4 If apparatus is contained in a sealed carrying container, marking shall be on the container.

7.5 The marking shall be as clearly visible and as durable as possible.

7.6 Facepiece and its packaging (if used), shall be marked with:

a) Name, trade-mark or other means of identification of manufacture,
b) Size (if more than one size available), and
c) Year and month of manufacture.

7.7 BIS Certification Marking

The product may also be marked with the Standard Mark.

7.7.1 The use of the Standard Mark is governed by the provision of *Bureau of Indian Standard Act*, 1986 and the Rules and Regulations made thereunder. The details of condition under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

8 SAMPLING AND CRITERIA FOR CONFORMITY

8.1 Lot

All the chemical oxygen (KO_2) type self generating, self rescuers of the same class and made from the same material and produced under similar conditions of manufacture on the same day shall constitute a lot.

8.1.1 All the lots shall be tested separately for testing the conformity of the lot to the requirements of the specification.

8.2 The number of samples to be drawn from the lot shall depend upon the size of the lot and shall be as per Table 1. The samples shall be selected at random from the lot. For this purpose, reference may be made to IS 4905.

Table 1 Scale of Sampling

Sl No. (1)	Lot Size (2)	Sample Size (3)
i)	Up to 150	15
ii)	151 and above	20

8.3 Number of Tests and Criteria for Conformity

8.3.1 The sample selected according to col 2 of Table 1 shall be checked visually for the requirements of design [*see* **5.1**(a) and (b)], materials/components (*see* **5.2.1**), harness (*see* **5.5**), handling (*see* **5.6**), facepiece (*see* **5.8.1** to **5.8.3**), goggles (*see* **5.9.1**), inhalation and exhalation valves (*see* **5.10**), relief valves (*see* **5.11.1**), instruction for use (*see* **6**) and marking (*see* **7**).

8.3.1.1 The lot shall be considered as conforming to the above requirements, if there is no failure. Otherwise, the lot shall be rejected.

8.3.2 Samples already found satisfactory as per **8.3.1**, shall further be tested for the requirements of design [*see* **5.1**(c)], materials/components (*see* **5.2.2** and **5.2.3**), cleaning and disinfection (*see* **5.3**), mass (*see* **5.4**), leak tightness (*see* **5.7**), facepiece (*see* **5.8.4**), goggles (*see* **5.9.2**), relief valve (*see* **5.11.2** and **5.11.3**), breathing bag (*see* **5.12**), resistance to temperature (*see* **5.13**), flammability (*see* **5.14**), mechanical strength (*see* **5.15**), performance (*see* **5.16**) surface temperature (*see* **5.17**), practical performance test (*see* **5.18**) and if required, additional requirement for apparatus designed for special use (*see* **5.19**).

8.3.3 The lot shall be considered as conforming to the requirements of the specification, if no defect is found in the requirements tested as per **8.3.2**.

ANNEX A

(*Clauses* 4, 5.13, 5.15, 5.16.1, 5.16.2, 5.16.3, 5.16.4, 5.16.5, 5.16.6.1, 5.16.6.2, 5.17, 5.19.1.4 *and* C-2)

LABORATORY PERFORMANCE TEST

A-1 GENERAL PERFORMANCE

A-1.1 A schematic arrangement of the equipment required for this test is shown in Fig.1 The equipment consists mainly of a breathing machine of main and auxiliary lung with solenoid valves controlled by the breathing machine, a cooler, a humidifier, a connector, a flow of carbon dioxide gas with flowmeter for carbon dioxide, analyzers for carbon dioxide, oxygen and meters for temperature and pressure. The total volume of the gas path excluding the breathing machine of the test rig should not exceed 2 000 ml.

A-1.2 Breathing Machine

The test equipment shall subject the apparatus to a respiration cycle by the breathing machine, such that when measured the volume of gas shall be of a value as given in Table 2 at a relative humidity of 95 to 100 percent and at a temperature of 37 ± 0.5°C. The carbon dioxide content shall be of a value as specified in Table 2 in addition to the carbon dioxide content of the inhaled air.

A-1.3 Inlet Carbon Dioxide

The carbon dioxide is fed into the breathing machine via a control valve, a flowmeter, a compensation bag and non-return valves.

A-1.4 Measurement of CO_2 in Exhalation

Immediately behind the humidifier a small quantity of exhaled gas shall be continuously withdrawn through a sampling line and then fed into the exhaled air via a carbon dioxide analyzer in front of the humidifier to measure carbon dioxide content in exhaled air.

A-1.5 Cooler

A cooler of volume 500 - 1 000 ml shall be inserted in inhalation line. *See* Fig. 2 (for reference only).

A-1.6 Humidifier

Shall saturate exhaled air with humidity to 95 - 100 percent. The temperature of the exhaled gas after

Table 2 Test Conditions

(*Clauses* A-1.2 *and* A-1.7)

Sl No.	Minute Volume		Equivalent Flow l/min	Input of Carbon Dioxide l/min	Carbon Dioxide Content of Exhaled Gas Percent
	Respiration Cycles/min	Lung Volume Litres/Stroke			
(1)	(2)	(3)	(4)	(5)	(6)
i)	10	1.0	10	0.4	4.0
ii)	20	1.75	35	1.575	4.5
iii)	30	2.33	70	3.5	5.0

humidifier shall be checked and adjusted at the temperature measuring point in the connector before starting the test (approximately 37° ± 0.5°C) [*See* Fig. 3 (for reference only)].

A-1.7 Measurement of CO_2 and O_2 in Inhalation

To measure the carbon dioxide and oxygen content of the inhaled air an equivalent amount as specified in Table 2 of the main lung volume/inhalation is drawn off continuously at the marked place as shown in Fig. 1 by an auxiliary lung during the inhalation phase and fed to an oxygen analyzer and a carbon dioxide analyzer.

A-1.8 Apparatus Connectors

Depending on the facepiece of the apparatus, different connectors shall be used for the test.

Apparatus with a full face mask shall be tested on a dummy head (Sheffield head). Schematic diagram is shown on Fig. 4. Apparatus with a mouthpiece assembly shall be tested using a connector in accordance with Fig. 5.

A-1.9 Measurement of Temperature and Breathing Resistance

The temperature of the inhaled and exhaled gas is measured at points marked in figure by means of a fast response thermocouple (for example, thermowire NiCr-Ni, 0.25 mm diameter) and fast sensing differential pressure transmitter.

A-1.10 Recording

The oxygen content and the carbon dioxide content as well as the temperature of the inhaled and exhaled gas and the breathing resistance shall be measured and recorded continuously.

The test shall be conducted at room temperature (23 ± 2°C).

A-2 PERFORMANCE AT HIGH MINUTE VOLUME

During a test on the breathing machine the minute volume shall be increased to 70 l/min for a certain period. The time when the adjustment to the high minute volume is made depends on the class of apparatus under test:

a) *For apparatus with a rated duration of 30 min or more* — The increase in minute volume shall be made 15 min before the rated duration is achieved. After 5 min the breathing machine shall be readjusted to 35 l/min and the test continued.

b) *For apparatus with a rated duration between 10 and 25 min* — The 70 l/min period shall be started 5 min after the start of the test.

c) *For apparatus with 5 min rated duration* — Apparatus shall be tested separately at a minute volume of 35 l/min and 70 l/min. Each test condition applies to the entire duration.

A-3 SURFACE TEMPERATURE

The surface temperature shall be measured during performance tests on the breathing machine. During a test with a minute volume of 35 l/min and in addition during a test with a minute volume of 35 and 70 l/min thermocouples shall be connected to points expected to turn hot. The temperature shall be measured and recorded continuously until the test is finished.

The highest temperature shall be recorded.

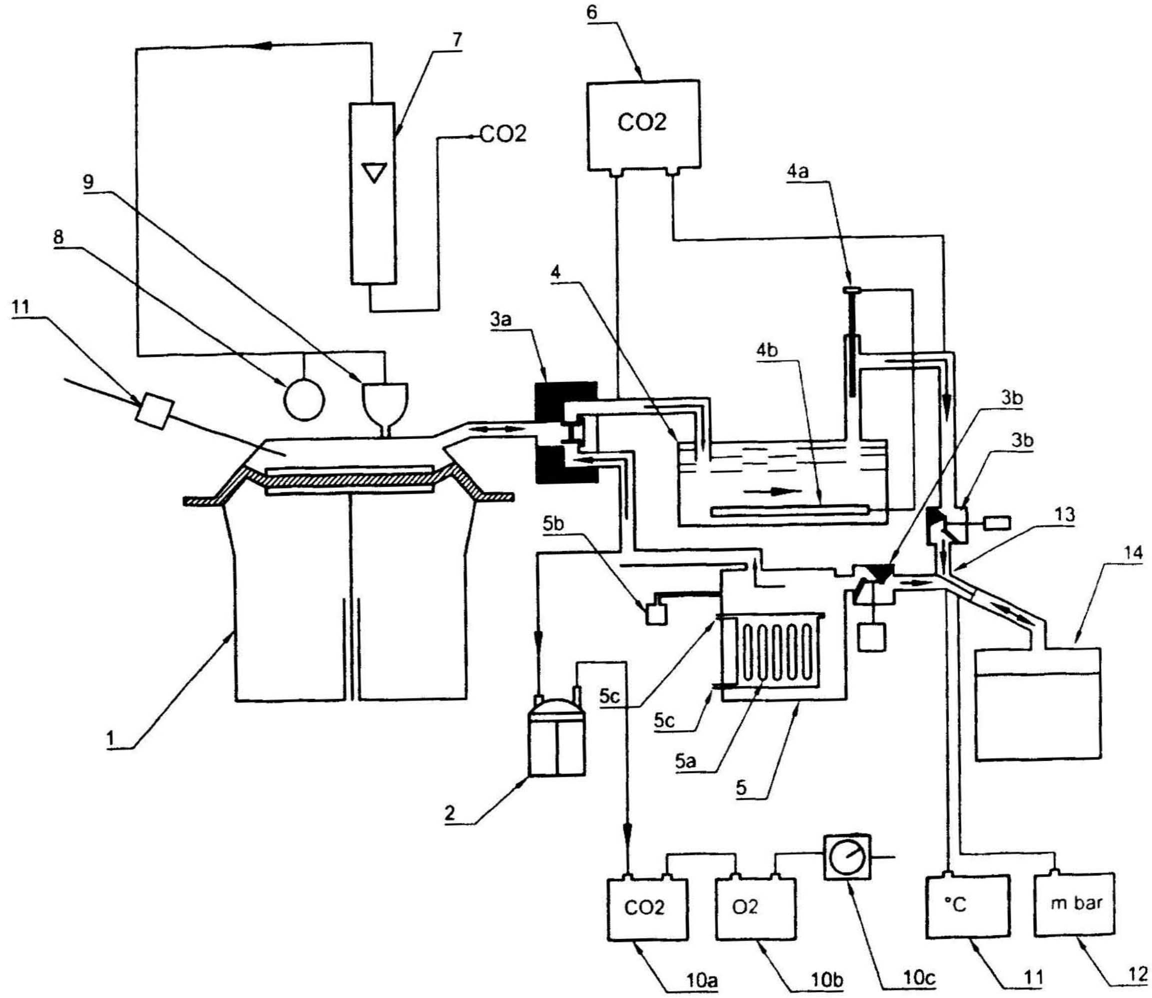
A-4 BREATHING RESISTANCE

The breathing resistance shall be measured during the breathing machine tests described in general performance test.

For apparatus with a full face mask the breathing resistance shall be measured at the mouth of the dummy head.

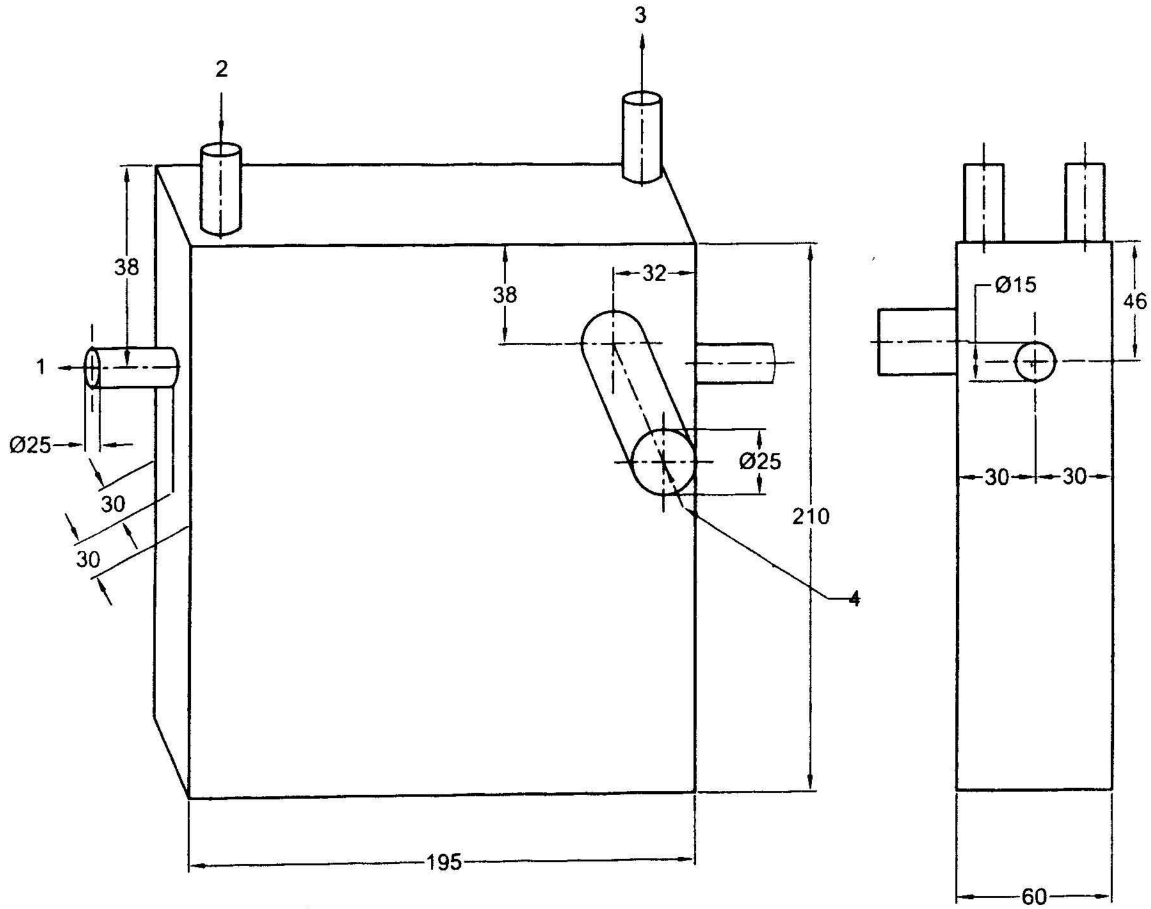
For apparatus with a mouthpiece assembly the breathing resistance shall be measured at the connector.

The breathing resistance is measured by means of a fast response pressure meter.



1. Sinusoidal Flow Breathing Machine
2. Auxiliary Lung
3. Valve System
3a. 3 Way Valve
3b. Solenoid Valve
4. Air Humidifier
4a. Contact Thermometer
4b. Heating Element Controlled by the Contact Thermometer
5. Cooler Chamber
5a. Cooling Ribs
5b. Container for Condensed Water
5c. Water Inlet and Outlet
6. Carbon Dioxide Analyzer for Exhaled Gas
7. Rotameter for CO_2
8. Compensation Bag
9. Non-Return Valve
10. Inhaled Gas Analysis
10a. Carbon Dioxide Analyzer (Connected to Recorder)
10b. Oxygen Analyzer
10c. Gas-Meter for Sampling Gas
11. Temperature Measuring Equipment with Plotter
12. Pressure Meter with Plotter
13. Connector
14. Test Specimen

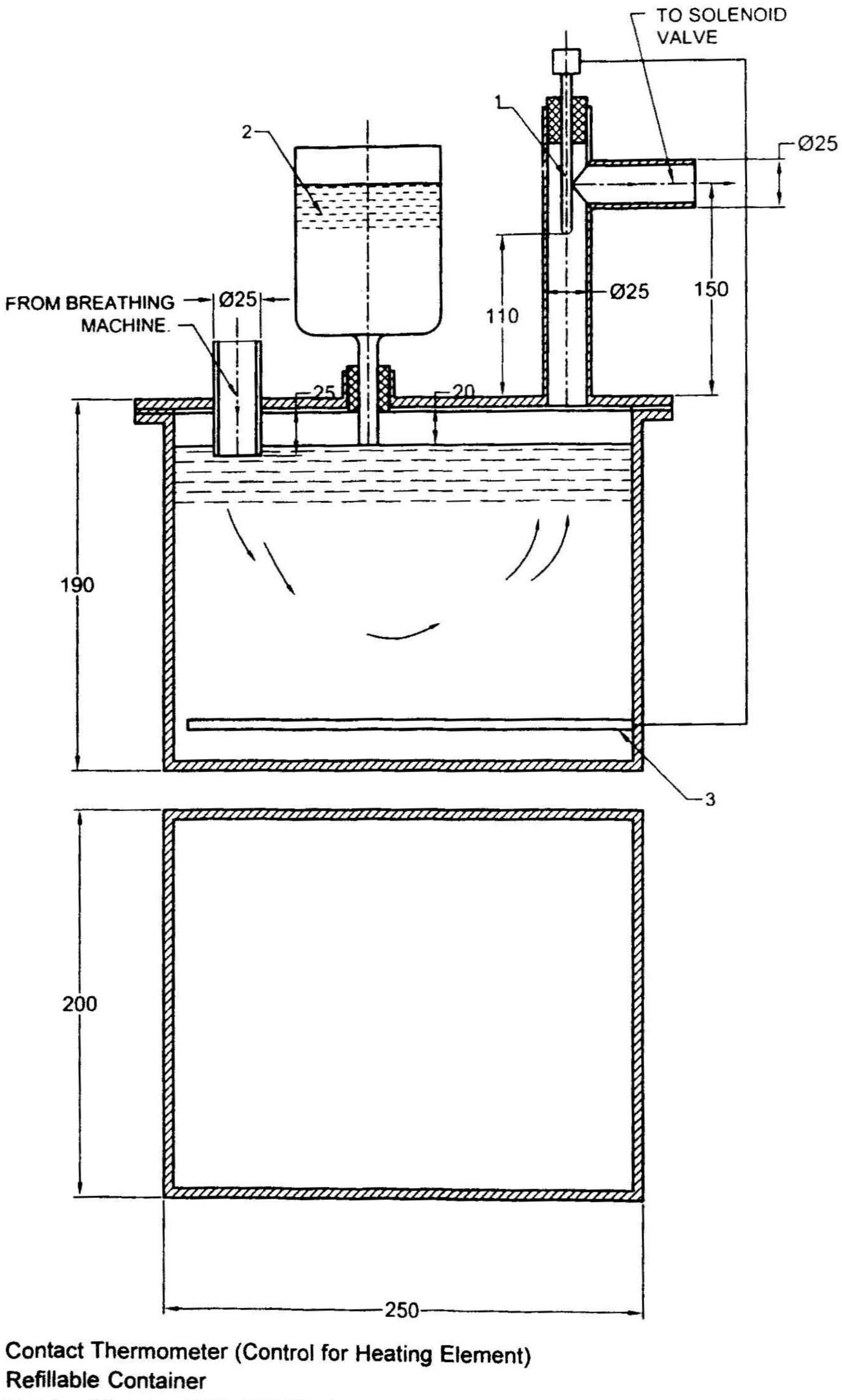
FIG. 1 SCHEMATIC ARRANGEMENT FOR LABORATORY PERFORMANCE TEST



1. To Breathing Machine
2. Cooling Water In
3. Cooling Water Out
4. From Solenoid Valve

All dimensions in millimetres.

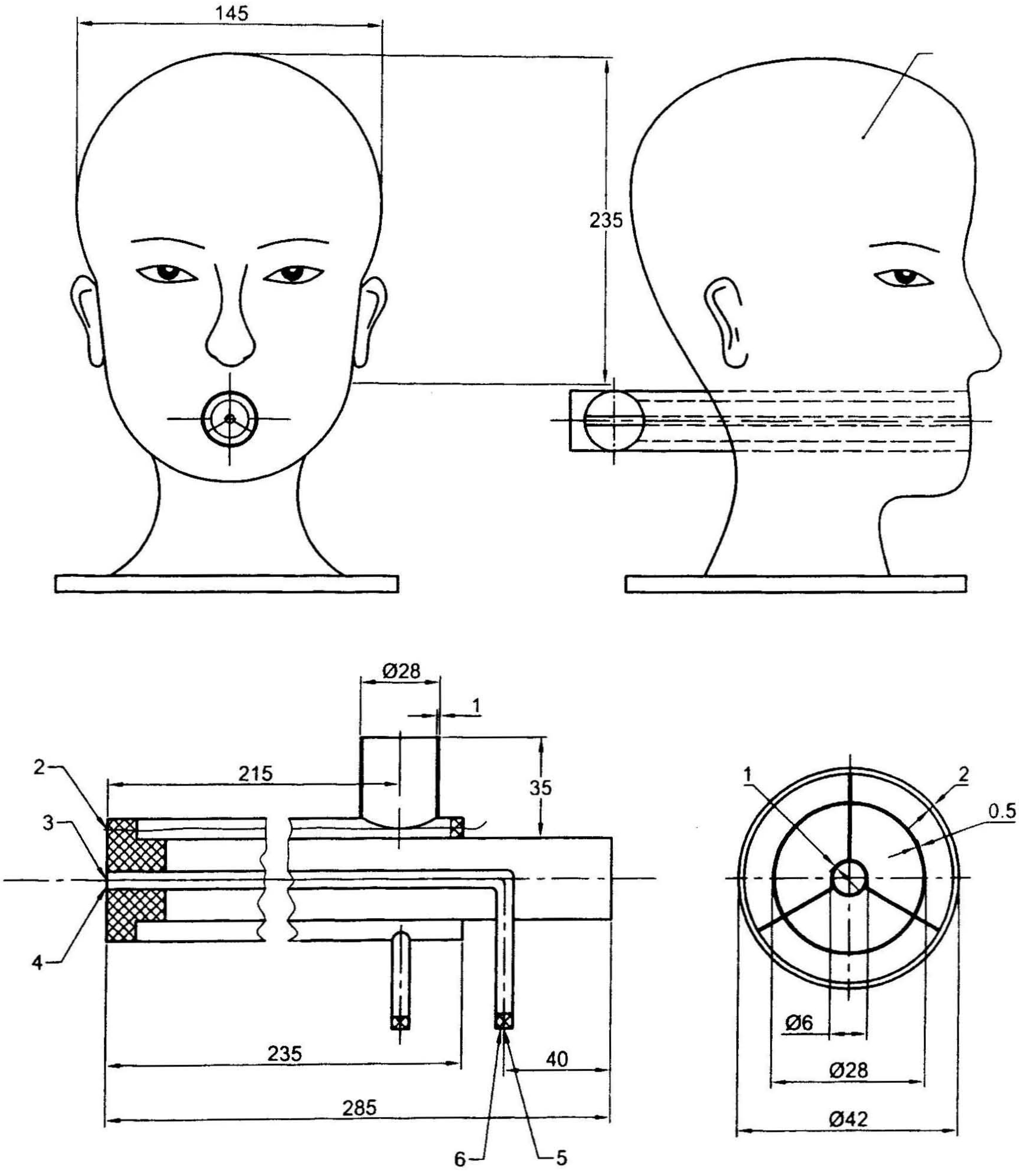
FIG. 2 COOLER — LABORATORY PERFORMANCE TEST



1. Contact Thermometer (Control for Heating Element)
2. Refillable Container
3. Heating Element (250-300 Watt)

All dimensions in millimetres.

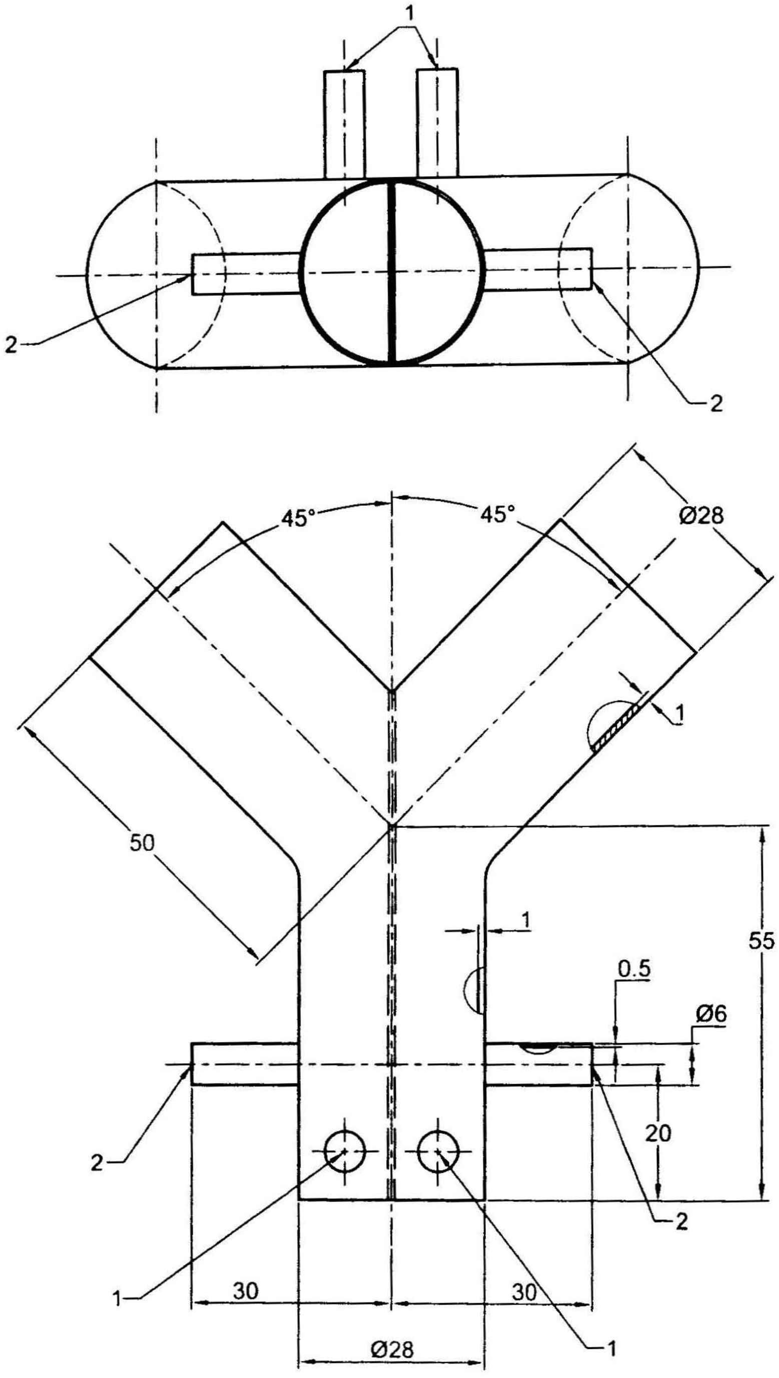
FIG. 3 HUMIDIFIER — LABORATORY PERFORMANCE TEST



1. Sheffield Head
2. Temperature Measuring Point (Exhalation)
3. Temperature Measuring Point (Inhalation)
4. Pressure Measuring Point
5. Thermocouple
6. To Pressure Guage

All dimensions in millimetres.

FIG. 4 DUMMY HEAD FOR APPARATUS WITH PERMANENTLY CONNECTED FULL FACE MASK — LABORATORY PERFORMANCE TEST



1. Pressure Measuring Point 2. Temperature Measuring Point

All dimensions in millimetres.

FIG. 5 '*Y*' PIECE CONNECTION FOR BREATHING APPARATUS HAVING PERMANENT MOUTHPIECE ASSEMBLY — LABORATORY PERFORMANCE TEST

ANNEX B

(*Clauses* 5.1, 5.2.2, 5.9.2, 5.16.2, 5.16.3, 5.16.4, 5.16.5, 5.17 *and* 5.18)

PRACTICAL PERFORMANCE TEST

B-1 The test shall be performed with two apparatuses and four test subjects. Two tests shall be conducted for escape test as per **B-3** and test at rest as per **B-4**.

B-2 TEST SUBJECTS

The apparatus is to be tested by the test subjects who practice regularly with the apparatus and whose medical history is known to be satisfactory. Test subjects shall be medically examined immediately before the test and certified fit to undertake the test procedure. Each subject shall be suitably clothed. During test the test subject perform at different work levels.

B-3 ESCAPE EXERCISE IN TEST HOUSE

B-3.1 General

Satisfactory operation of the apparatus under practical conditions is checked by performing escape test. The apparatus under test is worn by test subject. The test subject performs at different work loads. The average minute volume shall be approximately 35 l/min and at rest approximately 10 l/min. At the start of the test, in case of an apparatus without starter, the wearer shall exhale 2-3 breaths into the apparatus. In case of an apparatus with starter the wearer shall wait to see the breathing bag inflated by starter or else by exhaling into it as directed in the instruction manual.

B-3.2 Test Procedure

B-3.2.1 The test subject shall be instructed for use of the correct procedure of opening, donning and of the operation of the apparatus. The test subject shall carry out the procedure in dark without assistance. The test subject shall be accompanied by assistance during test.

B-3.2.2 Following shall be recorded before starting the test:

a) Name,
b) Age,
c) Height, and
d) Weight.

B-3.2.3 Following shall be recorded at various points of the escape route as well as on the mass of ready to use apparatus:

a) Temperature, and
b) Relative humidity of the atmosphere.

B-3.2.4 Following shall be recorded during the test:

a) Nature and time of the different activities; and
b) Complaints (namely, discomfort, visibility, etc).

B-3.2.5 Following shall be assessed by the test subject for the apparatus after test:

a) Comfort of breathing, and
b) Comfort of wearing.

B-3.3 Escape Exercise in Test House

B-3.3.1 The exercises shall be carried out at an ambient temperature of 30 ± 10°C which are recorded. Ambient atmosphere shall be free of smoke and air flow shall be negligible. Following shall be monitored periodically throughout the test:

a) Oxygen content of inhaled gas,
b) Carbon dioxide content of inhaled gas, and
c) Breathing resistance.

B-3.3.2 An exercise shall be terminated when the either of following occurs:

a) Generation of oxygen ceases,
b) Inhalation breathing resistance reaches 35 mbar, and
c) There is evidence that the test subject is no longer capable of completing the exercise.

B-3.3.3 *Escape Exercise for Apparatus with Rated Duration of More than Thirty Minutes*

Practical simulation of conditions that are expected to prevail during escape exercise shall be done in the test. Following activities shall be performed during the testing:

a) Walking on treadmill for a total distance of 133 m at a speed of 8 km/h for 1 min,
b) Walking on treadmill for a total distance of 220 m at a speed of 3.3 km/h for 4 min,
c) Walking through training gallery for 23 min,
d) *Exercise in Training Gallery* — Training gallery includes level and rising roadways of varying heights and climbs of 15 m on a ladder at rate of approximately 10 m/min. Using a fixed ladder it may be necessary to ascend and descend the ladder several times to cover the total distance of 15 m climb, and
e) Walking on treadmill for a total distance of 80 m at a speed of 2.4 km/h and 20 percent inclined for 2 min.

The number of exercises depends on the classes of apparatus. The final part of the practical exercise may be carried out on the treadmill (walking on lever ground at a speed of 5 km/h.

B-3.3.4 *Escape Exercises for Apparatus with a Rated Duration of Up to and Including Thirty Minutes*

Following activities shall be performed during testing:

a) Walking on treadmill at speed of 8 km/h for 1 min, and
b) Walking on treadmill at speed of 2.4 km/h and 20 percent inclined until the test is terminated.

B-3.3.5 *Escape Exercise Underground*

These are additional tests to be carried out with chemical oxygen (KO_2) escape apparatus for use in underground mining. For these four exercises shall be carried out using four test subjects. Applicable test conditions shall be used correspondingly.

B-4 TEST AT REST

One test shall be carried out. The test subject shall not perform any work. During the test the subject shall sit comfortably. The apparatus may be placed so that the subject is not impeded by the mass. Following shall be measured continuously and recorded :

a) Temperature of inhaled gas,
b) Oxygen content of inhaled gas,
c) Carbon dioxide content of the inhaled gas, and
d) Breathing resistance.

The exercise shall be terminated when oxygen generated or the oxygen content of inhaled gas reduces to less than 21 percent (by volume) or carbon dioxide content in inhaled gas is increased to more than 1.5 percent (by volume) or test subject is no longer capable of completing the exercise.

ANNEX C

(*Clauses* 5.2.2 *and* 5.13)

RESISTANCE TO TEMPERATURE

C-1 CONDITIONING

The apparatus shall be conditioned by the flowing thermal cycle:

a) 72 h in a dry atmosphere of 70 ± 3°C,
b) 72 h at 70 ± 3°C and at 95 - 100 percent relative humidity, and
c) 24 h at –30 ± 3°C.

C-2 LOW TEMPERATURE LABORATORY TEST

For performance test at low temperatures the complete apparatus shall be exposed to a temperature of –5°C to –7°C for 20 h. Subsequently the apparatus shall be tested at room temperature with a minute volume of 35 l/min in accordance with general laboratory performance tests mentioned in **A-1**.

C-3 LOW TEMPERATURE PRACTICAL PERFORMANCE TEST

C-3.1 Preparation of Apparatus

Two apparatuses, ready for use, are stored at a temperature of –5°C to –7°C for a period of 4 h.

C-3.2 Test Procedure

Two warmly clothed subjects don the apparatus in a cold chamber with an ambient temperature of approximately 0°C but less than 5°C and shall then walk at a steady rate of 6.5 km/h. The walking may be conducted on a treadmill.

During the test the oxygen and carbon dioxide content of the inhaled air shall be measured continuously. The duration of the walking shall be for a period of 10 min. For apparatus with a rated duration of 5 min the test has to be carried out for 5 min. After this test the test subjects shall leave the cold chamber and return to ambient conditions and continue walking at a steady rate of 6.5 km/h for 5 min. After the test the apparatus shall be examined for malfunctions and the subjects shall report on the breathing comfort and wearing characteristics.

ANNEX D

(*Clause* 5.2.3)

INSULATION RESISTANCE OF NON-METALLIC CARRYING CONTAINER

D-1 The resistance is tested on carrying container if size permits or on test piece as shown in Fig. 6 comprising of rectangular plate on which two parallel electrodes are painted on the surface using a conducting paint with a solvent which has no significant effect on the insulation resistance.

D-2 The test piece shall have an intact surface and shall be cleaned with distilled water, then with isopropyl alcohol or any other solvent that can be mixed with water and will not affect the material of the test piece, then once more with distilled water before being dried. It shall then be conditioned for 24 h at the temperature of 27 ± 2°C and 65 ± 5 percent relative humidity.

D-3 The test shall be carried out under the ambient conditions. Any suitable device (for example, megger) to measure insulation resistance can be used for this test. The direct voltage applied for one minute between the electrodes shall be equal to 500 ± 10 V. During the test, the voltage shall be sufficiently steady so that the charging current due to voltage fluctuation will be negligible compared with the current flowing through the test piece. In certain cases this requires the use of batteries or accumulators.

The insulation resistance is the quotient of the direct voltage applied at the electrodes to the total current flowing between them when the voltage has been applied for 1 min.

ANNEX E

(*Clauses* 5.7, 5.13, 5.14.2, 5.15 *and* 5.19.1.4)

LEAK TIGHTNESS

E-1 LEAK TIGHTNESS OF THE CARRYING CONTAINER

Testing of the apparatus including carrying container shall be conducted by total immersion in water of approximately 40°C for 5 min. No bubbles shall be observed escaping from the container. In addition the test specified by the manufacturer shall be used, if available.

E-2 LEAK TIGHTNESS OF THE READY-TO-USE APPARATUS

The leakage test of the ready for use apparatus shall be checked before and after tests for resistance to temperature and flammability test. The apparatus is to be tested with dry air at a positive and negative pressure of 7.5 mbar.

NOTE — During the positive pressure test the relief valve shall be closed.

ANNEX F

(*Clauses* 5.11 *and* 5.11.3)

RELIEF VALVE

F-1 OPENING PRESSURE

The relief valve shall be checked without being dismantled and when the apparatus is in use position. The opening pressure shall be measured with a suitable pressure meter. It shall be attached to the facepiece for this test. 1.5 l/min of dry oxygen shall be fed into the apparatus through the facepiece. The maximum value recorded shall be taken as the opening pressure.

F-2 LEAK TIGHTNESS

F-2.1 Leak-Tightness for Downstream Valves

F-2.1.1 *Test Equipment*

Test equipment consists of:

a) A leak tight box having small volume between 1 to 1.2 l, attached to a tube with opening(s) between the box and tube in which the valve assemblies are mounted in suitable adaptors of low dead space as shown in Fig. 7. There are baffle plates in the box to promote smooth test gas flow (100 l/min continuous flow).

b) A breathing machine delivering sinusoidal air flows corresponding to 10 cycles/min and 1.0 l/stroke.

c) A test gas of one percent SF_6 or any suitable tracer gas.

d) A humidifier to saturate the air with water vapour at 37°C.

e) An instrument capable of measuring SF_6/ suitable tracer gas used.

Schematic diagram of test rig is shown in Fig. 8 and Fig. 9. Either of this can be used.

F-2.1.2 *Test Procedure*

All relief valve assemblies attached shall be tested.

The test shall be performed at ambient temperature and relative humidity of 27 ± 2°C and 65 ± 5 percent RH. The valve assemblies under test shall be fitted into the box with suitable adaptors in a vertical position. The components shall be arranged according to whether a single or twin cylinder breathing machine is to be used.

The inlet valve shall be adjusted so that the back pressure of the valve(s) is 1 to 1.5 mbar at 30 l/min continuous flow.

The breathing machine shall be set at 10 cycles/min, 1.0 l/stroke. A flow of test gas shall be maintained through the box. Samples of the gas from before and after the valve assemblies shall be continuously analyzed for test gas concentrations.

The test shall be run for a sufficient time to obtain a steady reading of the test gas concentration in the inhalation gas stream.

The difference in the test gas concentrations between the two samples is a measure of the total valve leakage.

F-2.2 Leak-Tightness for Mechanical Operated Valves

For the leak test the effective volume of the test chamber shall be 500 ml.

ANNEX G

(*Clause* 5.12)

BREATHING BAG TEST

G-1 PRINCIPLE

The effective volume of the breathing bag with relief valve is determined by removing the air from the breathing bag in the pressure range from the opening pressure of the relief valve to a negative pressure of 5 mbar.

G-2 APPARATUS

G-2.1 Any Suitable Gas Meter

G-3 PROCEDURE

The effective volume of the breathing bag without relief valve is determined by removing air from the breathing bag in the pressure range from a positive pressure of 2 mbar to a negative pressure of 5 mbar.

Report the volume measured by the gas meter.

ANNEX H

(*Clause* 5.14.1)

FLAMMABILITY

H-1 PRINCIPLE

The effects of the flame on the apparatus shall be observed after passing it once through a defined flame. The test is run in normal air without the presence of oxygen from KO_2.

H-2 APPARATUS AND TEST RIG

The apparatus shall be so orientated that the component to be tested passes through the test flame. The apparatus is on a support that enables it to be rotated by means of a motor to describe a horizontal circle. The test rig is shown schematically in Fig.10.

A gas supply rig consisting of a propane/LPG storage cylinder with flow control device, pressure regulator, flash back arrester and a burner that shall be adjustable in height as referred in Fig.10.

The temperature of the flame at height of 20 mm above the burner tip shall be 800 ± 50°C. The temperature shall be checked with a suitable measuring instrument. In order to obtain a steady flame it may be necessary to provide a shield around the burner as outlined in figure.

H-3 PROCEDURE

The apparatus shall be positioned and it shall be ensured that the speed corresponds to 60 ± 5 mm/s. The apparatus shall be rotated such that the component to be tested is over the burner.

The position of the burner shall be adjusted such that the distance between the top of the burner and the lowest part of the components to be tested that is to pass through the flame is 20 mm. The apparatus shall be rotated away from the burner. The gas at the burner shall be ignited and the gas pressure/flow shall be adjusted. It shall be ensured that the burner air vent is fully closed and the flow control valve shall be adjusted to give a flame height of 40 mm above the burner tip.

For the test the sample shall be passed once through the flame at 60 ± 5 mm/s, when component such as valves, etc., are arranged on other part of the apparatus the test shall be repeated such that any part is passed only once through the flame.

ANNEX J

(*Clause* 5.15)

MECHANICAL STRENGTH

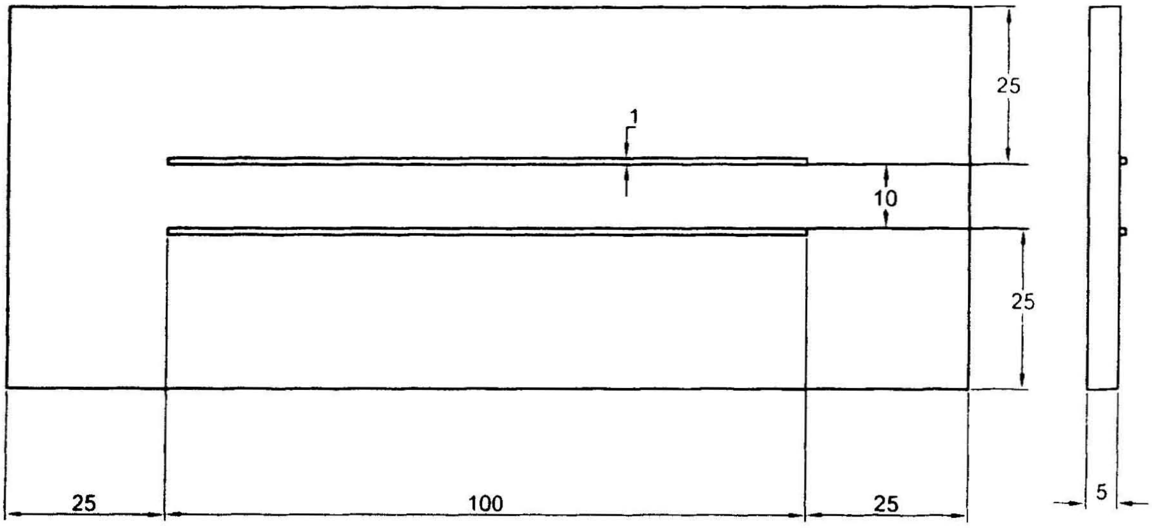
J-1 SHOCK TEST

In order to test the resistance to shock the apparatus shall undergo 3 times a free fall from a height of 1.5 m onto a concrete floor.

J-2 VIBRATION TEST

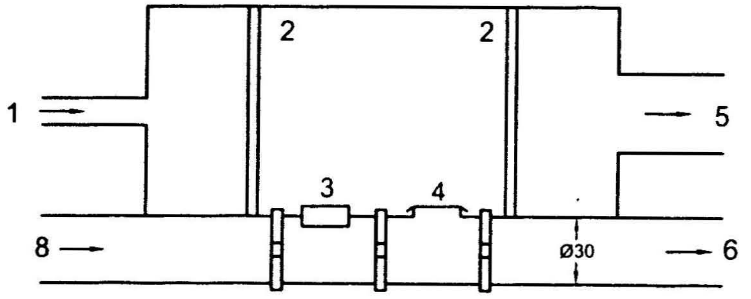
The test apparatus is shown schematically in Fig.11. Test apparatus consists of a steel case (*K*) which is fixed on a vertically moving piston (*S*) capable of being lifted up 20 mm by a rotating cam (*N*) and dropping down onto a steel plate (*P*) under its own mass as the cam rotates. The mass of the steel case shall be more than 10 kg.

The apparatus shall be tested as received including carrying container and sealing. The apparatus shall be placed in the case (*K*) so that they do not touch each other during the test allowing 6 mm horizontal movement and free vertical movement. The test rig shall be operated at the rate of approximately 100 rotations/min for a total of 500 rotations (5 min).



All dimensions in millimetres.

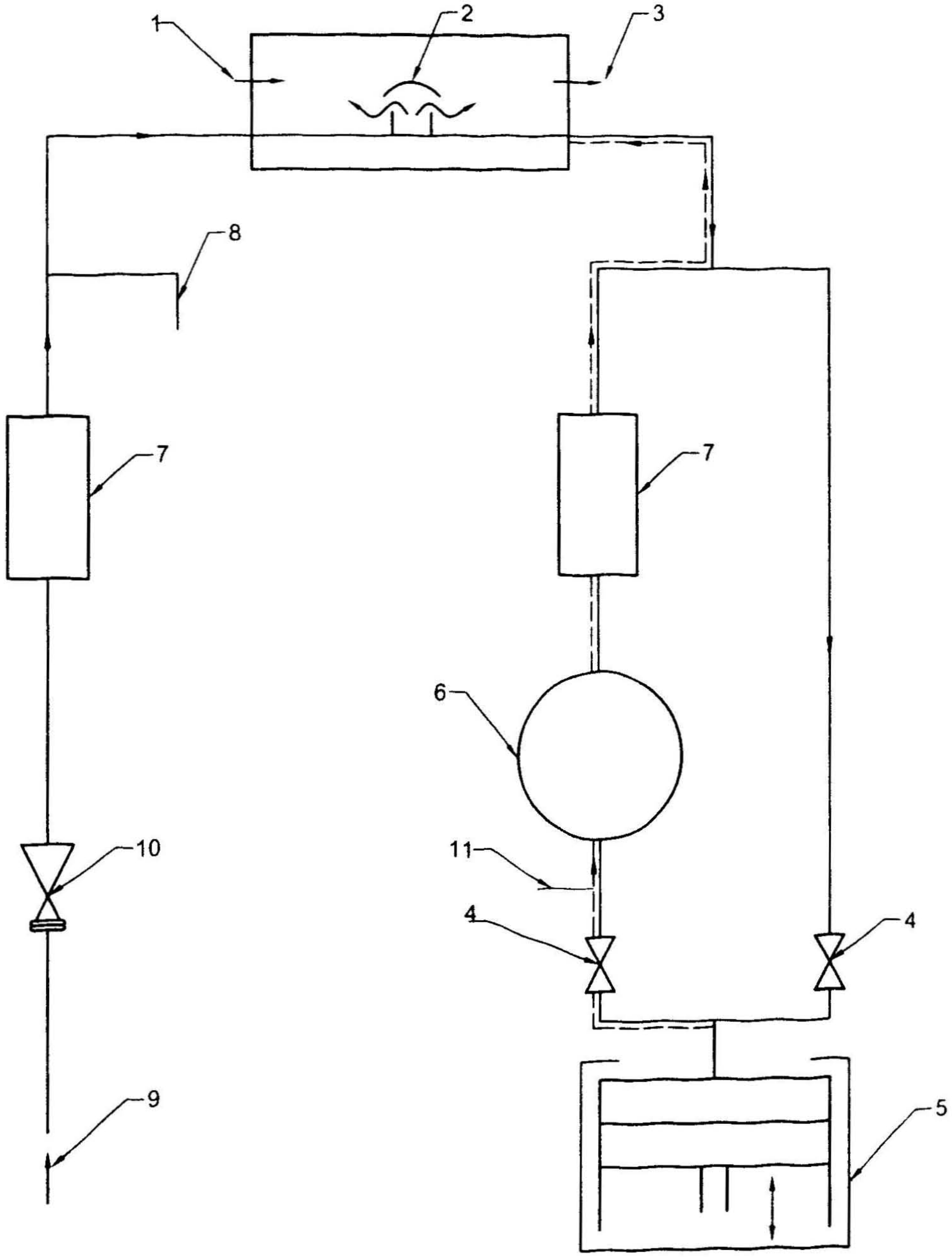
FIG. 6 RECTANGULAR PLATE WITH PAINTED ELECTRODE FOR INSULATION RESISTANCE TEST OF NON-METALLIC CARRYING CONTAINER



1. Test Gas In
2. Baffle Plate
3. Blanking Plate
4. Valve Under Test
5. Test Gas Out
6. To Breathing Machine
7. Pressure Measurement Port
8. Saturated Gas In

All dimensions in millimetres.

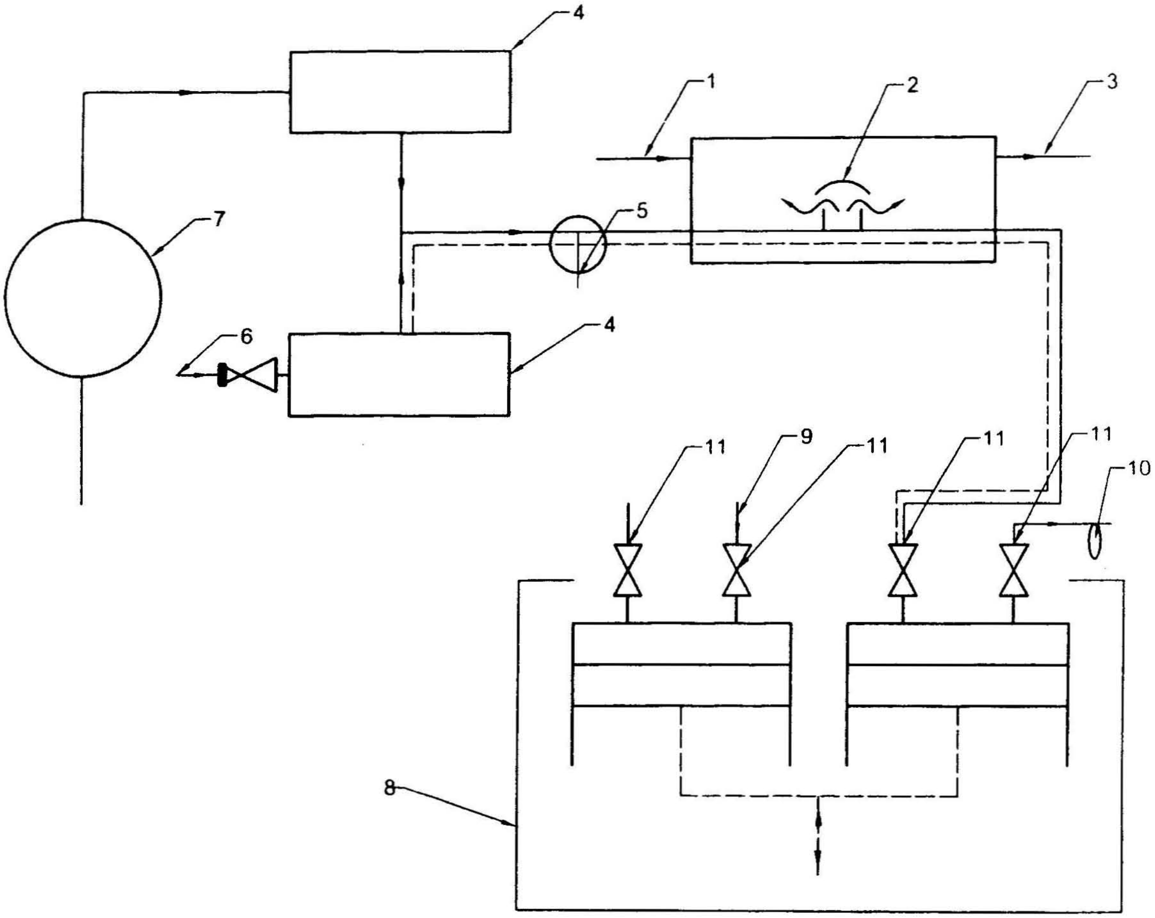
FIG. 7 LEAK-TIGHT BOX FOR RELIEF VALVE LEAKAGE TEST



1. Test Gas In
2. Valve Under Test
3. Test Gas Out
4. Breathing Machine Valve
5. Breathing Machine
6. Saturator
7. Purifier
8. Reference Gas Sample
9. Laboratory Air In
10. Adjustable Non-Return Valve
11. Test Gas Sample

NOTE — The difference between the concentration of sample taken at Points 8 and 11 is measure of the valve leakage.

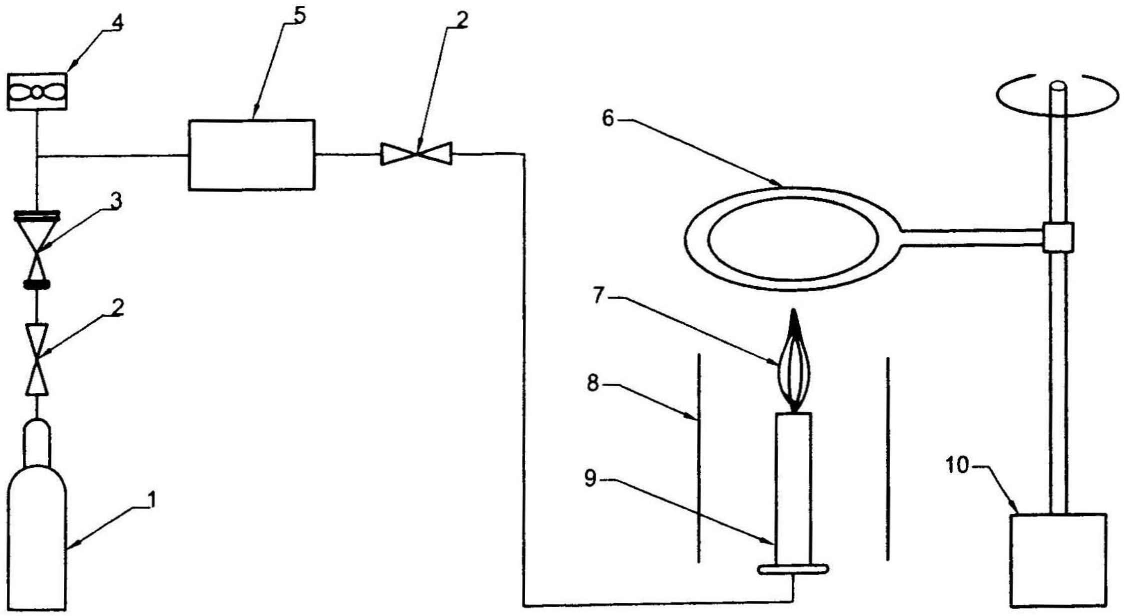
FIG. 8 RELIEF VALVE LEAKAGE TEST USING A SINGLE CYLINDER BREATHING MACHINE



1. Test Gas In
2. Valve Under Test
3. Test Gas Out
4. Purifier
5. Reference Gas Sample
6. Laboratory Air In Through Adjustable Non-Return Valve
7. Saturator
8. Twin-Cylinder Breathing Machine
9. Laboratory Air In
10. Test Gas Sample
11. Breathing Machine Valve

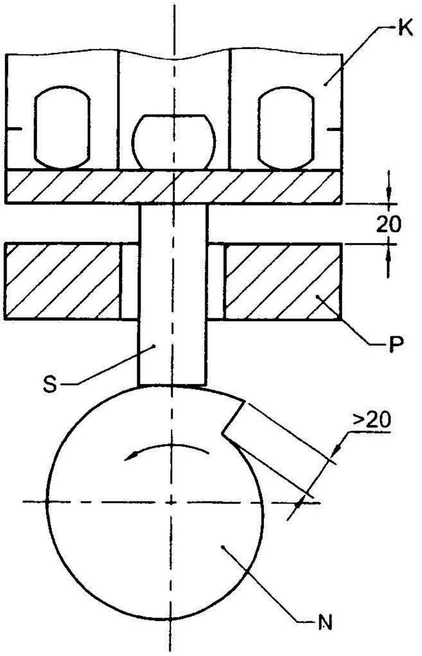
NOTE — The difference between concentration of sample taken at Points 5 and 10 is of the valve leakage.

FIG. 9 RELIEF VALVE LEAKAGE TEST USING A TWIN CYLINDER BREATHING MACHINE



1. Propane/LPG Cylinder
2. Valve
3. Pressure Regulator
4. Pressure Gauge
5. Flashback Arrestor
6. Support for Apparatus
7. Flame
8. Shield
9. Burner
10. Motor and Speed Control

FIG. 10 SCHEMATIC TEST RIG FOR TESTING OF FLAMMABILITY



K - Steel Case
S - Vertically Moving Piston
P - Steel Plate
N - Rotating Cam

All dimensions in millimetres.

Fig. 11 Schematic Diargram of Apparatus Used for Mechanical Strength Vibration Test

ANNEX K

(Foreword)

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Scientist 'E' (CHD), BIS

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Telephones : 2323 0131, 2323 3375, 2323 9402

Telegrams : Manaksanstha
(Common to all offices)

Regional Offices : Telephone

Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg
NEW DELHI 110 002
2323 7617
2323 3841

Eastern : 1/14 C.I.T. Scheme VII M, V. I. P. Road, Kankurgachi
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